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REPORT

of

TECHNICAL ASSISTANCE

to

SAWMILL INDUSTRY

of

SOUTHERN PERU

by

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Central States Forest Experiment Station, U.S. Forest Service
Columbus, Ohio

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SUMMARY

During the period from July 31 to October 26, 1965, a sawmill specialist supplied by the U.S. Forest Service worked with a number of sawmill operators in the Peruvian Departments of Cuzco and Madre de Dios. The objective of the program was to provide technical assistance which would improve efficiency and productivity of the operators who supply lumber products to towns and cities in southern Peru. The services of the specialist were also used by the Forest Service of Peru, the Department of Forest Science in the Agricultural University at La Molina and the owners of Hacienda San Ramon in Yurimaguas.

The sawmill specialist's assignment was the result of a request originating with the Industrial Development Division of the Cuzco Reconstruction and Development Corporation. The parent sponsoring organization, the Peruvian National Productivity Center of Lima, approved the project which was implemented through cooperation of the U.S. Agency for International Development, the U.S. International Agricultural Development Service, and the U.S. Forest Service. A Participating Agency Service Agreement between AID and USDA was executed to cover the details of service.

The major services performed included conferences and demonstrations with both individual sawmill operators and groups of operators. Subjects that were covered included planning and setting up sawmills, grading and storage of logs, operation and maintenance of sawmill machinery, segregating and storage of lumber, air seasoning and kiln drying, and utilization of residues. No one was available from any Peruvian agency for training to continue the program of sawmill assistance, but as a temporary expedient three American Peace Corps Volunteers were trained to serve until suitable replacements are available.

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INTRODUCTION

In June 1965, a request from Peru for a sawmill specialist reached the Forest Service of the U.S. Department of Agriculture. This specialist was to work under the general policy guidance of the Director of USAID/Peru and under the sponsorships of the Peruvian National Productivity Center (CENIP) and Cuzco Reconstruction and Development Corporation (CRIF).

The originator of the request was Mr. Charles Jackson of the Stanford Research Institute and Resident Advisor to Corporación de Reconstrucción y Fomento del Cuzco (CRIF). Discussion of the problems of the sawmill industries and of the related wood-using industries of southern Peru with AID officials and persons attached to the Servicio Forestal y de Caza of Peru led to the conclusion that the following general areas needed analysis and required action on the part of the specialist and cooperating parties:

1. Storage and grading of logs prior to milling.
2. Sawmill operation, including selection and installation of machinery, machinery maintenance, operating techniques, and quality control.
3. Grading and storage of lumber, including seasoning-air drying and kiln drying.
4. Utilization of by-products.

The concept as originally proposed was to hold a series of meetings for the purpose of discussions and demonstrations aimed at improving lumber quality, sawmill efficiency and productivity. It was soon discovered, however, that meetings with more than one lumberman were almost impossible to arrange because of communication and transportation difficulties. Therefore, conferences were held with the individuals, either at the site of their sawmills, at their lumberyards in Cuzco, or both. Production problems, industry marketing problems, and action programs that would improve the overall economic situation for the millmen were discussed at these meetings. Several times, also, the steps of checking mill alignment and operating efficiency were carried out.

The conclusions drawn from conferences with mill operators and from the visits to their lumber manufacturing facilities corroborated the observations of other persons interested in the sawmill industry of southern Peru. There were opportunities for observing forest conditions in two other areas also. The general impression was that there were forest resources in Peru that could easily meet the national demand for wood products provided that the problems of low productivity could be solved and the barriers to distribution could be removed.

The forests of southern Peru which were of lumber-producing importance occurred on the eastern Andean slopes and on the tropical upper Amazon plains. They were characterized by many different species per unit area, although in limited or localized sites there were concentrations of only

a few species. Some of the sawmill operators of southern Peru planned to saw only one species, in which event they found areas in which the desired species occurred in almost pure stands, or they found a tree or two per acre scattered throughout the forest. This policy has resulted in "high grading" the forests, an undesirable forestry practice, but it was the only feasible policy under the prevailing economic conditions. Thus, a handful of species, such as cedro (Spanish cedar), caoba (mahogany), tornillo, moenas, and nogal (walnut) were the principal trees cut for lumber purposes in southern Peru. There were a few other species sold by name in the southern Peru markets, but the majority of species other than those named fell into the classification of "corriente." These latter had local names, but their botanical descriptions were often as obscure as their physical and mechanical properties.

Logging methods varied from the most primitive of manual felling, bucking and skidding to the more sophisticated techniques in which logs were skidded by tractors. Not once, however, was anything other than axe and crosscut saw encountered in the forest, and even where tractors were found, they were ill-equipped and/or too small to skid the logs efficiently. The complete lack of chainsaws was probably explained by a reluctance to place a comparatively dangerous instrument in the hands of unskilled operators. The unavailability of parts and the necessity to train operators in care and maintenance might have been other deterrents. Chainsaws may become a necessary item, however, when sawmills reach a production capacity that requires a larger volume of logs. Low-capacity logging met the needs of low-capacity sawmills, but there were signs that this condition will not prevail much longer.

One of the major problems in the utilization of southern Peru's forests was the occurrence of many species per acre. As previously mentioned, there were instances where only a tree or two per acre were cut, and because of inadequate skidding equipment development of a sound lumber industry is delayed. Little was known of the properties and characteristics of more than the handful of high-value species. Economics of production, distribution, and marketing limited use to only a few species. The sawmill operator was not willing to risk a loss on unknown species when he knew that there was a profit in the high-value species. Architects and engineers who designed wooden members in structures knew the characteristics of only a few species. Even when one species was specified, it sometimes could not be obtained in sufficient quantity and quality to meet the requirements.

In spite of the problems of lack of knowledge of species characteristics and the difficulties of production, transportation, and marketing, there was evidence that the lumber industry of Peru was on the brink of great expansion. Several sawmill operators proposed to expand present operations or to establish new forest products enterprises. The most obvious impression received from 2 1/2 months of work with those in the forest products industries was that they realized the tremendous potential that exists in the forests of southern Peru, and they want to contribute to the realization of this potential. Although imagination was lacking on the part of some of the sawmill operators, there were a few who were willing to tap the resources of the forest by means of their intelligence, capital, and hard

work. These men were thinking in terms of sawmills which will saw 6 to 10 times the present rough average of 1,500 board feet of lumber per day. They were considering also the possibility of veneer and plywood plants and other wood-based industries, such as particle board, fiberboard, and paper products.

The potential exists for a large volume of high-quality wood products from the forests of southern Peru. These forests are a renewable resource, and under proper management they will be a continuing contributor to the wealth of the country.

CONDITIONS OBSERVED AT SAWMILLS

Table 1 on page 6 shows the conditions that were encountered at 13 mills visited in the three areas of Quince Mil, Puerto Maldonado, and Ccosnipata. Individual reports have been prepared for each mill, and a copy of the report has been supplied to each owner and to CRIF.

In general, these sawmills exhibited very low productivity, mostly attributable to inadequate power units, logs much too large for the equipment, badly filed and fitted headsaws, lack of edgers, and poor operating techniques. Average production per day ranged from 1,000 to 2,500 board feet, although when it was producing large cants the daily production of one mill was reported to be as much as 4,000 board feet. All mills were using circular headsaws of 6, 7, or 8 gauge, and none had a top saw.

With two exceptions, all sawmills were located in towns, or were on or near major highways. The two exceptions were mills which were set up on, or near, the timber holdings of the operator, and the roads to the mills were very poor. Stream beds served as roads for some distances in both cases. This stage of development was similar to that which existed in the United States 20 years ago, when small portable mills were moved frequently from one timber tract to another at frequent intervals. However, as transportation of logs has improved, mills tend to become stationary and permanent, and this same trend was evident in these areas of Peru.

Only 4 of the 13 sawmills visited were less than 10 years old, and all of them were manufactured in the United States. With three exceptions, maintenance had been fair to excellent. The machinery had been required to operate under conditions for which it was not designed, and it speaks well for both the equipment manufacturers and the sawmill operators that the machinery was still capable of producing lumber. The mills ran the gamut from very poor foundations and mediocre machinery installation to heavy, poured concrete bases and excellent alignment. One man in the Ccosnipata area was responsible for installing most of the sawmills there, and in every case foundations were sound and alignment of tracks, shafts, and bearings was good. There was much evidence of "Yankee ingenuity" where improvising was necessary to overcome the lack of proper equipment or the difficulty of obtaining replacement parts.

One universal and very questionable practice was the piping of a stream of water to the headsaw to keep the saw constantly wet. All the manufacturers of large, circular headsaws question this practice, which was ostensibly for the purpose of reducing friction and the consequent heating and loss of tension in the saw. Every sawmill, with two exceptions, was using a headsaw that needed to be checked for tension and rehammered, which in itself was evidence that water on the saw during sawing was no panacea. In most cases the saws were being held in line by the guides. This is a bad practice and it is unnecessary when the saws are properly fitted and the mill well-aligned.

Most of the mills used high-speed steel, inserted saw teeth. The hardness of the high-speed steel reduced the filing frequency and to some extent decreased the problem encountered when sawing woods containing silicate crystals. These high-speed teeth, however, cost about \$1.50 each,

Table 1.--Summary of characteristics of 13 sawmills in southern Peru

| Mill No. | Make and age of mill | Power source and hp. | Edger | Trimmer | Planer | Sawdust removal | Lbr. rolls | Condition of equipment | Cleanliness of work area | Daily production bd. ft. | Hrs. per day | Prod. per hour | No. of men | Prod. per man hour | Seasoning practices | Species |
|----------|----------------------|----------------------|---------|---------|--------|-----------------|------------|------------------------|--------------------------|--------------------------|--------------|----------------|------------|--------------------|-------------------------|-------------------------|
| 1 | N.O.M.B. 3 yrs. | Diesel 159 | Yes | No | Yes | Manual | Yes | Fair | Good | 1,500 | 8 | 187 | 5 | 37 | None | Mixed |
| 2 | Frick 25 yrs | Diesel 45 | No | No | No | Manual | No | Poor | Fair | 1,000 | 8 | 125 | 4 | 31 | None | Mixed |
| 3 | American 25 yrs. | Gas 60 | No | No | No | Water | No | Fair | Fair | 1,500 | 8 | 187 | 4 | 47 | None | Mixed |
| 4 | Frick 20 yrs. | Gas 65 | No | No | No | Water | No | Poor | Fair | 2,000 | 8 | 250 | 4 | 63 | None | Mixed |
| 5 | Frick 25 yrs. | Diesel 60 | No | No | No | Water | No | Fair | Fair | 1,000 | 8 | 125 | 4 | 31 | None | Tornillo, mixed |
| 6 | N/A 10 yrs. | Gas 70 | No | No | No | Water | No | Fair | Fair | 1,000 | 8 | 125 | 4 | 31 | None | Mixed |
| 7 | Frick 20 yrs. | Diesel 80 | No | No | Yes | Water | No | Good | Good | 1,000 | 8 | 125 | 4 | 31 | None | Mixed |
| 8 | Meadows 5 yrs. | Gas 85 | No | No | No | Manual | No | Good | Good | 1,500 | 8 | 187 | 4 | 47 | X-racks | Cedro, caoba some mixed |
| 9 | Frick 15 yrs. | Diesel 54 | No | No | Yes | Manual | No | Good | Good | 2,200 | 8 | 275 | 4 | 69 | X-racks minimum 15 days | Cedro |
| 10 | Meadows new | Diesel 85 | Yes | Yes | No | Water | No | Excellent | Good | 2,500 | 8 | 312 | 5 | 62 | None | Tornillo, mixed |
| 11 | N/A 20 yrs. | Gas 30 | No | No | Yes | Water | No | Fair | Fair | 1,500 | 8 | 187 | 4 | 47 | None | Tornillo, mixed |
| 12 | Frick 9 yrs. | Diesel 85 | Rip saw | Yes | Yes | Water | No | Excellent | Good | 2,500 | 8 | 312 | 4 | 78 | None | Mixed |
| 13 | American 25 yrs. | Diesel 85 | No | Yes | No | Water | No | Very poor | Poor | 1,500 | 8 | 187 | 4 | 47 | None | Tornillo, mixed |

and in the large 56- to 60-inch saws that had from 40 to 48 teeth, they represented a heavy operating expense. One result of the high price of saw teeth was a tendency to grind the cutting edge very lightly in such a way that the cutting angle was gradually increased far beyond an efficient angle. Teeth, in new condition, had a cutting angle of 35 to 37 degrees. After a period of use and filing this angle was observed to be 45 degrees and more in many sawmills. This reduced the efficiency of sawing seriously because of the increased horsepower required to drive the blunt teeth through the wood. Tooth holders, or "shanks" as they are sometimes known, were in many instances badly worn. They had to be shimmed with thin metal strips to prevent their becoming loose enough to slip from the sockets during sawing. The face of some of the holders were rounded and hollowed out as though they had been sandblasted.

One interesting feature of the mills was the sawdust disposal system. Nine of the sawmills had a small stream channeled under the husk frame to carry away the sawdust and splinters. This also carried away any bark pieces that fell from the logs during sawing. The other mills used a manual system of sawdust removal, usually a wheelbarrow or other cart, in which the sawdust was wheeled to a dumping area. Slabs were piled and burned in some cases, and in others, they were dumped over the bank of nearby rivers. In no case were they being cut up for fuel wood or used for any other purpose.

Only one mill of all those visited could be said to have adequate power. This was the mill operated by the Peruvian Army Engineers at Rio Salvación, and, through a misunderstanding, they were not using the full power available to them. The GM diesel in this mill had a rating of 159 continuous horsepower, but the operators were under the mistaken impression that they had only about 85 hp. Gasoline power units ranged from Fordson tractors with about 30 hp. at the power-take-off through motors up to 85 hp. Some of these were motors from Chevrolet and Dodge automobiles while others were from trucks. Only one appeared to be an industrial type motor. The diesel power units were usually in good condition and ranged from a 45 hp. Caterpillar industrial unit, through a Volvo unit of about 85 hp., to the previously mentioned sawmill of the Army Engineers. One unique power unit was a single-cylinder Deutz diesel which according to its owner developed 60 hp. The operator of the mill with the Fordson tractor was in the process of installing a 20-foot-diameter overshot waterwheel to drive his sawmill through a system of pulleys and belts. As a result of the low-to-moderate horsepower, most of the mills had very slow feed rates, which resulted in low productivity. Horsepower alone does not control production, but it is a major factor.

Arrangement of the sawmills was generally poor. Apparently no information on mill layout was available to most of the operators at the time of mill installation. In almost every instance, material was moved manually from log deck to carriage, from carriage to storage or separation points, from mill to yard, and in every other step of production. No attempt had been made to install simple materials handling devices, such as lumber rolls. Where there was an auxiliary machine, such as an edger or trim saw, it was placed in an awkward position for feeding and removal

of material. The glaring error in many instances was the failure to arrange flow of materials to utilize gravity for movement. In one extreme case, the carriage truck was sunk below ground level and boards dropped from the carriage at floor level. This required the offbearer to bend completely over to pick each board from the floor. Lack of good mill layout, both horizontally and vertically, was a major contribution to low productivity.

Seasoning of lumber varied from none at all to a minimum period of 15 days. Mills that shipped lumber via air freight from Puerto Maldonado to Quince Mil were interested in at least partially air drying. This was accomplished by X-racking the lumber for as long as they could hold the lumber in inventory, or a minimum of 15 days. The mills which shipped by truck preferred to ship green, because the lumber was converted to income in a shorter time. There was no demand from customers in Cuzco and other points for dry, or partially dry, lumber, so the millmen could not realize added income by drying. The practice of the secondary industries and the lumberyards of buying wood in the form of heavy timbers and resawing it on simple circular table saws to the sizes required for their own or customer use was another complicating factor. If these timbers were dried, they would split and check, and the pieces cut from them would be quite defective. There was seldom a demand for a large quantity of lumber of a given size, so that cutting to order at the sawmill was practically non-existent.

Most of the mills preferred to saw only one or two high-value species, and the two mills at Puerto Maldonado, at least, concentrated their sawing on cedro. One of them, however, took species such as caoba (mahogany), castanea (Brazil nut), and others. Tornillo was the prized species in the foothill forests, but most of the mills sawed a great many species. Some were very soft; some, medium hard; and some, extremely hardwoods. Most of the mills sawed logs much larger than the carriages or the headsaw were designed to handle. This practice resulted in very slow production first because it was difficult to move logs manually from the log deck to the carriage. Second, the saw did not reach through the log and the first and subsequent slabs had to be chopped free by hand. Third, the turning of the very heavy logs required the entire crew. The sawmill axiom that it is just as inefficient and uneconomical to saw logs that are too large for a mill as it is to saw logs that are too small was well demonstrated.

If one general conclusion were to be drawn from observation of the sawmills of southern Peru, it would be that not a single mill was observed that could be classified as "complete." Every mill was lacking in at least one fundamental factor that would have resulted in greater production. In some cases it was an improperly fitted headsaw; in others it was too little power, poor layout, lack of an essential piece of equipment such as an edger, no material handling equipment, to name a few examples. The sawmill operators were an intelligent group of men and their failure to achieve the potential production capabilities of their equipment was largely a matter of lack of information and assistance in solving their problems. They appeared to be operating at a profit, but in almost every instance they were letting the lack of a few hundred dollars for an essential

piece of equipment handicap their production. Another possibility is that they did not realize the potential increase in productivity that is afforded by such comparatively low cost equipment as a chainsaw, a new headsaw, lumber rolls, an edger, etc.

While on the subject of the "complete sawmill" it is appropriate to emphasize the lack of equipment for moving logs on the yard and especially for turning the logs on the carriage. In some mills even such simple tools as cant hooks were lacking, or sadly in need of repair. A cant hook can so easily be made by a blacksmith who has a sample for a guide that this lack is inexcusable. The absence of any kind of turning aid was another example of lack of equipment. No powered turners were installed, and it was necessary to enlist the aid of the entire mill crew to turn large logs. Even simple turning blocks to be placed on the log deck skids were not used because of lack of knowledge regarding them.

DISCUSSION AND RECOMMENDATIONS FOR IMPROVEMENT OF SAWMILL EFFICIENCY AND PRODUCTIVITY

TIMBER CONDITIONS, SPECIES, SIZES, WOOD PROPERTIES

There is little that the sawmill operator in southern Peru can do to improve the stand conditions as they exist today. He may find 50 or more species per acre and know the properties and the market value of only a few. There are two things that he can do to improve the situation, however. First, during the felling he can separate trees that have similar characteristics. Logs falling into similar use categories can be placed together so that sawing of similar species is done at one time. Second, he can segregate those species that are most valuable and speed them to the sawmill for immediate sawing, so that there is no loss from degrade because of stain and insects.

The sawmill man is in a quandary when confronted with particularly large-diameter trees. Generally, large trees yield large, clear logs, but they may overtax the logging and transporting equipment, and they are not necessarily economical to process. They can cause serious delays and equipment failure during logging. Unless the sawmill operator has equipment to handle the very large logs or to reduce them to smaller sizes in the woods he should leave large trees uncut. Some operators have been known to slab the four sides of large logs with axes to reduce their size. It is possible that chainsaws could be used for the same purpose and perform the work much faster. Also, chainsaws could be used to halve or quarter logs before they are skidded to the landing. Naturally, this system is not practicable if the logs are rolled by hand, but a small tractor could move logs in sections which it could not move as a whole log.

Much still needs to be learned about wood properties of Peruvian species. Cooperating organizations in Peru, such as the Servicio Forestal, La Molina Agricultural University, and United States agencies can contribute much to the development of the lumber industry by determining the properties of Peruvian woods as rapidly as possible. At first this may be simply the grouping of woods by appearance, grain characteristics, hardness, resistance to decay, color, odor, ease of drying, etc. More involved research to determine engineering characteristics for the design of wooden structures could come later.

LOGGING AND TRANSPORTATION

One of the real problems associated with increasing productivity at the sawmill is that of maintaining production in the woods to meet the increased need for logs. At the present time there are already indications that log delivery may be pinched by such factors as shortage of suitable labor, increasing hauling distances from stump to roads or streams, equipment too small to handle the raw material, too few marketable species, etc. The answer is to provide the logger with modern equipment designed to handle the available logs. Chainsaws and tractors, and possibly simple cable skidding equipment are the most likely items to meet the need. Immediately, the small operator develops into a larger operator when he

gets this kind of equipment. Through some means, sources of capital must be made available to him so that he can invest in machinery that will withstand the heavy loads, the rough terrain, and adverse working conditions. Using chainsaws to fell and tractors with integral arches, the operator can skid tree-length logs to a landing (truck or water) where the logs can be bucked to shorter length for secondary transportation. At present, crawler tractors would be the most effective single unit, but, when the operators have grown sufficiently in financial and production stature, a combination of crawler and rubber-tired tractor will be even more efficient. Trucks will be more efficiently utilized when better roads are provided and loading from roadside cribs or by cross hauling will permit faster loading and larger loads.

LOG STORAGE AT THE SAWMILL

At the present time log storage is hardly a problem, but if production is increased, it could become one. In order to saw more hours per day, more days per week, and more weeks per year there must be good planning and business management acumen on the part of the sawmill operator. This involves carrying an inventory of logs for times of low log production. Where the operator can store logs in water without danger of losing them to floods or waterlogging, there is no better way to prevent log damage for long periods of time. Hardwood mills in the United States sometimes apply continuous sprays to log decks so that logs can be kept in good condition for many months, but it requires special equipment which the Peruvian operator may not find practical for land storage. If logs are to be stored for any length of time a solution of pentachlorophenol and benzene hexachloride sprayed on the logs has been effective against both stain and decay. Even painting the ends of logs with roofing asphalt will be helpful, especially in preventing end checking.

MANUFACTURING

Location and Mill Layout

It is interesting to note that, with the exception of one or two mills, the operators of sawmills in southern Peru have concluded that it is advantageous to set a mill up on a permanent basis near a good road in order to attract better labor and to be where independent contractors can deliver logs easily. This has become the general practice in the United States also. Although independent logging contractors are not part of the sawmill picture at present, they will inevitably appear. They should be encouraged because they reduce the risk and capital investment required by the millmen. Good mill sites are not easily found in the foothill forest areas, and it may be necessary to convert a pasture or cropland area to a sawmill site if promises of return are more favorable to the sawmill than to the other use. If possible, the mill should have a slightly sloping site so that drainage is good, and the movement of logs into the mill should take advantage of the slope to the carriage. The mill itself should be arranged so that flow of material is always from higher to slightly lower elevations throughout the mill, from carriage headblock bases to offbearing table or rolls; to edger, trimmer, sorting area, loading dock, storage, or seasoning yard. A straight-line movement of lumber through the mill from one machine to another is also preferable.

Equipment

The major problem associated with the equipment that the lumbermen are using is size. The sawmills are almost always the smallest and lightest model made by the manufacturer. Although this reduces the original capital investment, it multiplies the operating difficulties. Even when set up on sound foundations, a small, light mill will soon deteriorate mechanically, especially when subjected to the pounding of very large logs as they are rolled on the carriage and turned for sawing. When financing becomes available, the sawmill operators should consider replacing their light trackways, small carriages, and undersize husk and feed mechanisms with sturdier equipment, even though the original cost may be considerably increased. If the lumber industry of southern Peru is to develop its potential, the present sawmill operators must stop thinking in terms of limited production and small mills. There must be a concept of efficient medium-size and large mills suitably engineered and powered to meet the conditions of timber and manufacturing requirements. Alternatives to heavier equipment is to saw only logs that fit the present mills, or to reduce the dimensions of large logs by splitting or ripping. Splitting or ripping may be economical and feasible at present labor costs, but in the long run better results will be attained by fitting the equipment to the material which is to be processed.

One very urgent need of the sawmill industry of Peru is the development of a "saw-doctor" service where headsaws that have been damaged by excessive stresses or heat can be repaired and properly tensioned. In several instances, saws are cracked at the mandrel hole. These had been repaired by riveting thin plates on each side of the saw blade. In each case the tension is improper and the saws are not sawing a straight line. In other instances, the mandrel collars are improperly ground so that the center of the saws are improperly supported. Another very serious problem is the lack of replacement holders for the saw bits. Most of them are badly worn except where the saw is comparatively new. The faces of the holders are rounded, and in some instances the abrasive action of sawdust has completely changed the original shape of the holders. Although oversize holders can be supplied by the manufacturers they are not used. When holders become loose they are shimmed with thin metal. Since saws are tensioned when the holders are securely inserted in the saw it is doubtful that more than two of the saws that were observed were properly fitted for the mill in which they were operating.

Saw teeth in the sawmills of southern Peru are generally high-speed steel which must be ground because it is too hard to file. They cannot be swaged because of their hardness, and clearance (set) on each side of the saw is reduced gradually as the bits are sharpened. More serious, however, is the tendency to change the sharpness angle of the tooth during grinding. The teeth are removed from the saws and ground on stones, usually by holding the saw bits in the hand or pliers. As long as the bits are ground straight across and the same sharpness angle maintained as in the original bit, this is a satisfactory practice. It would be of considerable help if the person sharpening the bits kept a new bit available as a pattern for sharpening. At least two or three hand- or electrically powered grinders are on the market for sharpening saw teeth without removing them from the saw. Investment in one of these units would probably pay for itself in the long run.

Attention needs to be directed putting the carriages into a better state of adjustment and repair. This is particularly important with regards to bolting the head blocks to the frame and removing slack in the knees. The former is a simple procedure, but the second adjustment may require reworking the keyways on the setshaft so that the pinions have no play on the shaft. The same thing can be done by driving a tapered pin through pinion and shaft and then taking up the adjustment between the pinion and rack on the knees. If the latter action is performed, it is important that the setworks be loosened and shimmed between the frame and setworks base so that no bind occurs in the setshaft.

Power Units and Requirements

Only one sawmill is adequately powered, although at least five mills are approaching a horsepower figure that would provide medium efficiency. However, even these six mills are not making good use of the power developed by their unit. In some instances the sawyer is "feeding" very slowly, and only a small portion of the power available is being used. In other instances, transmission equipment is inadequate. Pulleys, and particularly drive belts, are not wide enough for the transfer of power from one shaft to another. Another mistake is the use of high saw revolutions and slow "feeds," because this practice wastes horsepower. When sawing very dense woods, better production results if a short saw tooth is inserted in every other holder so that the effective number of teeth is cut in half. The "feed" can be maintained at normal speeds, and horsepower requirement will be reduced because of fewer teeth in contact with the wood at any one time. As previously mentioned, power requirements can be reduced also by maintaining the proper tooth angle when the teeth are sharpened.

None of the mills has saws less than 56 inches in diameter, and the maximum is 60 inches. Large-diameter saws require more power than small saws because of the long-lever type of reaction that develops when resistance to cutting is applied to a tooth and transmitted to the mandrel through the body of the saw. The sawmills of southern Peru need large saws for the large logs, but two modifications would help to relieve the excessive power requirements. One is to use saws with the minimum number of teeth that the manufacturer will supply as stock items; the other is to install a small top saw so that a smaller bottom saw can be used. This second solution will permit sawing larger logs, also, so that preliminary splitting of logs will not be necessary.

One of the known factors regarding power requirements for sawing is that doubling the feed rate, so that the amount of wood each tooth removes is doubled, does not double the horsepower required to remove the wood. Also, a saw tooth dulls just as rapidly when taking a thin bite as a thick one, so that it is inefficient to operate a saw at high revolutions per minute with slow feed with the idea that hardwood logs can be reduced to lumber more easily this way. Additionally, the longer the saw is in the cut the greater the opportunity for friction to develop between the body of the saw and the log with consequent heating and damage to the saw.

The practice of transmitting power from a motor to a saw mandrel with inadequate belt sizes is common. In one instance where an 8-inch belt

should have been installed a 5-inch belt is in use. As a consequence the 5-inch belt is slipping from the pulley frequently, resulting in considerable lost operating time. Only one mill is using V-belts; the rest are using flat belts. None of the mills is using an idler to provide better friction and contact between the belts and pulleys.

Sawing Techniques

The major factors influencing sawing techniques are the size of logs, the hardness of wood, and the power available. All these factors have been touched upon previously so that further discussion will be concerned with drawing the elements together. Where logs are too large for the carriage opening and the height of the saw blade, a number of techniques can be used. One already mentioned is splitting of the log into halves or quarters by means of manual pit saw or by chainsaw before it is placed on the carriage. As long as labor is plentiful and cost is low, this method is quite desirable. Some mills placed the log on the carriage and sawed a line through the middle. They then turned the log 180 degrees and sawed a line to meet the first line. This is a very risky practice, because, should the saw become jammed while buried in the log, there is danger of ruining an expensive saw. If the saw is not ruined when it jams, it still requires hours of chopping to release it and there is danger of the heavy log halves damaging machinery when they are released. Logs which are only a few inches larger than the maximum carriage opening may be sawed more advantageously by sawing only as deep as the saw can reach and still sever a slab or board. The log is then turned a small arc, instead of 90 or 180 degrees, and "slabbed" again. Sawing continues in this manner until the cant is of such a size that the saw can sever the slab or boards on each line. Admittedly, this method tends to waste some good-quality wood, but it more than compensates for this by eliminating the time lost during chopping when the saw does not sever the board from the log.

Almost without exception sawyers are not feeding the cant into the saw at a speed which the saw can stand without strain. There is a tendency to "baby" the saw through the cant or log even when sawing narrow faces. This could be attributed to a tradition of insufficient power, to the mistaken idea that slow feed is less damaging to saw teeth, to improperly filed saw teeth, or to the sawing of very hard woods. Many reasons advanced for slow feed, however, are more excuses than facts, and a program for training sawyers in production techniques should be carried out.

SEASONING

Any discussion of lumber drying, or seasoning, must begin with the premise that dry lumber is required by the customers or that a financial gain is to be made. In most of the mills in the Cuzco and Madre de Dios areas little or no seasoning is performed because the customers do not require dry lumber. However, those mills which must ship by air freight prefer to partially dry their lumber in order to save weight. This they accomplish by X-racking the lumber, a quick-drying method but one which encourages checking and warping. When employed, it is recommended that this method be used for only a couple of weeks while the surface of the

lumber is drying. It should be followed by flat piling with stickers at intervals of not less than 30 inches to hold the lumber straight.

One of the Peace Corps Volunteers investigated the possibility of setting up a crude type of kiln for drying lumber. At least one sawmill operator plans to install a kiln which will use waste from a sawmill as a heat source, and natural draft circulation to dry the lumber. The advantages, of course, are numerous. Transportation of dry wood is less costly than green. There is reduction of stain and insect attack, less checking and warping, and possibilities of opening up new markets by meeting secondary manufacturers' requirements more exactly.

TRANSPORTATION OF LUMBER PRODUCTS

The transportation of lumber in southern Peru, as well as in most of the rest of the country, is a major problem of the sawmill operators. High-value lumber is flown from Puerto Maldonado and Manu to Quince Mil by air freight and then loaded on trucks for further shipment by roads. The roads over the mountains are one-way, changing direction on alternate days, and they are designed for medium-size trucks. Average speeds are low because of the mountain grades and winding roads. About 2,500 board feet is the maximum truckload from the Quince Mil, Ccosnipata and Lares Valley areas.

Lumber which has traveled by airplane and truck to Cuzco from Manu or Puerto Maldonado has more than 50 percent of the selling price of 12¢ to 13¢ per board foot in freight cost. The sawmill operators in those two communities will soon have state-built roads to Quince Mil so that cost of transportation will be reduced greatly. They cannot use larger trucks to reduce unit costs because the roads are not designed for long, heavy trucks. Their one means of improving the shipping situation is to reduce the weight of the lumber by drying it before shipping. This permits larger truckloads, and it would appear to be a simple step. However, it is complicated by a number of economic factors, such as the high cost of carrying an inventory during drying, the extra cost of labor and materials for setting up a drying yard and stocking and unstocking the lumber, the loss of grade during seasoning, the possibility of stain and decay during slow drying periods, etc. The final deterrent to the shipping of dry lumber is that there is little or no price advantage for dry, or partially dry, lumber. It is likely, however, that as demand for lumber increases moisture content will become important, and the sawmill operator should plan his future operations to include facilities for drying.

QUALITY OF LUMBER AND MARKETS

An investigation of the markets for lumber in the Cuzco area brought out a number of points. First of all, architects and engineers are wary of specifying native species for construction purposes because they are dubious of the "quality" of the lumber. Investigation revealed that quality in the minds of the designers meant properties and characteristics and not freedom from injurious defects and appearance-marring blemishes. It is their contention that they cannot risk specifying native species when they do not know the strength properties nor the resistance to insect damage, or

other damaging agencies. This attitude strengthens the argument that immediate attention must be focused on acquiring the information needed by those people responsible for specifying the materials for construction.

At least three or four species are popular as furniture woods and are readily accepted by the furniture and cabinet manufacturers. There is no question about accepting cedro, caoba, tornillo, and moenes for high-quality furniture. Cedro is particularly adapted to intricate carving, and it appears in artistically carved chests and other articles. Caoba (mahogany) has no equal for many uses. Certain other woods are readily converted without trouble. The "corriente" or unknown species, however, present a problem, and it is among these woods that species equally as good as the more highly prized woods may be found when their properties are known. One interesting use for some of the harder woods is for parquet flooring, and this industry has great potential for expansion. Again, more knowledge is needed to determine which species combine the qualities of beauty of grain, wear-resistance, and low shrinkage and swelling.

Marketing is complicated in the Cuzco area by the small secondary wood-using industries and the limited amount of wood that goes into structures. If there were a demand for larger volumes of lumber, the sawmills could take cutting orders and plan to produce in large volumes. As it is, the users of lumber in the cities of southern Peru usually buy moderate quantities of boards, but much of their lumber comes to them in the form of timbers which are sawed to smaller sizes according to their specifications. There are no standard thicknesses or grades and this lack is one that should be corrected as soon as possible by coordinated efforts of the lumbermen. Everyone will benefit because marketing will be simplified and the volume of lumber used will increase.

RECOMMENDATIONS FOR A CONTINUING PROGRAM

INTRODUCTION

One of the most encouraging aspects of this project was the interest displayed by representatives and associates of the cooperating agencies in developing personnel who can carry out this work over a continuing period beyond that available to the author. Particularly gratifying was the interest and initiative displayed by the Peace Corps Volunteers, David Fielding, who was assigned to CRIF, and James Evrard, with the Servicio Forestal y de Caza. The officials of CRIF, the Servicio Forestal, and particularly Charles Jackson, Resident Advisor to CRIF for Stanford Research Institute, contributed greatly to the groundwork laid by our efforts. It is anticipated that after the departure of the technician for AID there will be a strong effort to continue assisting the lumbermen of southern Peru with their manufacturing and marketing problems.

One example of the kinds of programs that can be expected is shown by the following program proposed by David Fielding and James Evrard for a Sawmill Information Service. The full description of their proposal appears in Appendix F. It is respectfully requested that the Servicio Forestal y de Caza cooperate in this program to the extent of first contributing to the items shown under A-3, Budget, and eventually by taking a major part in the program with the assistance of the extension specialists from the College of Forest Science at La Molina Agricultural University.

CONFERENCES, DEMONSTRATIONS, AND CONSULTATION

Although the Peace Corps Volunteers assigned to the author as interpreters are still in the first stages of training, their interest in the program has given them a sound grasp of the fundamentals of successful sawmill establishment, operation, and maintenance. A third volunteer who arrived toward the end of the project has demonstrated a real interest, and he will remain in the area for about 2 years. Long before that time it is anticipated that joint efforts of cooperating forestry organizations will put a strong extension program in the field for the benefit of the lumber industry. Much sound and practical reference material has been made available to the men engaged in continuing this project. Within a short time Spanish language editions of the publications on small sawmills, saw filing and fitting, and lumber seasoning will be available for distribution to the sawmill operators in Peru. These publications will be invaluable in supplementing the visits by technicians to individual mills for consulting purposes, conferences with groups of lumbermen, and demonstrations of good sawmilling practices. The most effective disciple of the improvement program will be a satisfied customer, and when one sawmill man shows that he has derived benefits from the services extended to him the program will be in demand. The decision to extend this project further will depend on the interest shown and the skill of the extension workers in meeting the needs of those requesting assistance.

ASSOCIATIONS AND LUMBER STANDARDS

The formalities of forming an association of lumbermen--both producers and users--should be arranged as soon as possible. At the present time sawmill operation and marketing are complicated by the lack of standards for lumber, and this association should undertake a program to specify sizes and simple grades of lumber. The work will be most advantageously performed with the cooperation of the Servicio Forestal and the College of Forest Science at La Molina Agricultural University.

RESEARCH AND DEVELOPMENT

Every effort should be made to carry on a program of research to provide greater knowledge of the properties and characteristics of the species of trees available. This knowledge will prove invaluable in assisting the sawmill operator to manufacture and market more than the few high-value species that dominate the market at present, and to set prices on other species at a more realistic level. At the same time the release of a volume of species other than the present high-value ones will permit conservation of the more valuable trees. More knowledge of the properties of wood will enable the specifiers (architect, engineer, and designer) to describe more precisely the components of wooden structures and prevent faulty designs. The Servicio Forestal and La Molina Agricultural University will have a vital part in any program of research in cooperation with agencies from other countries, and everyone stands to benefit by this program.

THE POTENTIAL OF THE LUMBER INDUSTRY IN PERU

Although the lumber industry of almost every country has a backbone composed of many small sawmill operators, it is characteristic that many medium-size mills and a few large ones are responsible for more than half the total lumber production. As yet, Peru is primarily in a small mill lumbering economy. The great potential of Peru's forest for production of large volumes of lumber products can be most economically met by developing more medium and large sawmills. Efforts should be encouraged to establish these types of mills by financial assistance, tax concessions and timber-cutting programs. Many small mills can produce a small trickle of lumber, but larger mills produce a steady volume of well-manufactured lumber in large amounts and this is essential to establishment of a modern and efficient lumber industry.

APPENDIX A: SCHEDULE OF CONFERENCES AND TRAINING PROGRAMS

ITINERARY OF TRAVEL AND CONFERENCES

Week of August 2 - 7

In Lima, conferred with AID personnel, personnel of Servicio Forestal y de Caza, members of the faculty of the College of Forest Science, La Molina Agricultural University, and Ing. Jorge Succar R. of the Centro Nacional de Productividad. Travel to Cuzco August 7.

Week of August 9 - 15

In Cuzco, conferred with Director of AID program, officials of CRIF and of the Servicio Forestal, the Resident Advisor for CRIF, and the Peace Corps Volunteers assigned to this project. Traveled in CRIF vehicle with two members of the Servicio Forestal and two Peace Corps Volunteers to Quince Mil where conferred with operators of two sawmills, and by air to Puerto Maldonado where conferred with operators of a veneer mill and three sawmills.

Week of August 16 - 21

Returned to Cuzco by air and truck. Planned meetings with lumbermen with guidance from officials of CRIF and the SRI Resident Advisor; visited lumberyards in Cuzco and discussed program with lumbermen.

Week of August 23 - 29

Planned and conducted meetings with lumbermen under the auspices and with the cooperation and participation of officials of CRIF. Conferred with Col. Gomez of the Army Engineers regarding visit to their sawmill at Rio Salvación; observed operation of railroad crosstie yard at Huambutio.

Week of August 30 - September 4

Conferences with lumbermen in Cuzco. Travel by CRIF vehicle to Hacienda Hui-Hui in Lares Valley and evaluate plan for development of nogal timber for veneer and lumber (see Appendix B). Also advised hacienda owners on location of sawmill for lumbering operation and possible means for drying lumber by simple dry kiln.

Week of September 6 - 11

To area of Ccosnipata in CRIF vehicle accompanied by two Peace Corps Volunteers. Conferred with officers in charge of sawmill operated by Army Engineers at Rio Salvación and made recommendations for improvement of efficiency (see Appendix C); visited sawmills of Iwaki and Suero at Patria, Perez at Carbon, Monje near Pilcopata, Szkuta and Rojas near Chontachaca, and explained sawmill improvement program.

Week of September 13 - 18

Conferred with CRIF officials and SRI Resident Advisor, flew to Quince Mil with purpose of continuing to Manu to supply services to Barten-Lomalini sawmill operators but unable to obtain plane services. Visited Ortaru sawmill on outskirts of Quince Mil. Returned to Cuzco and prepared reports and discussed future programs.

Week of September 20 - 25

To Lima and Yurimaguas by air to discuss with operators of a large hacienda the problems and decision-making factors in connection with installation of a large sawmill. Returned to Lima and conferred with AID officials.

Week of September 27 - October 2

Developed plans for conferences with sawmill operators in Quince Mil area and for a sawmill improvement demonstration. Prepared outline for final report and conferred with CRIF officials. Prepared plan for simple dry kiln with Peace Corps Volunteers assigned to sawmill improvement program.

Week of October 4 - 9

To Quince Mil in CRIF vehicle accompanied by Peace Corps Volunteers and by operator of hacienda and sawmill in Quince Mil area. Visited mills of Pilares, Kalinowsky and Ortaru and invited them to attend demonstration at Stambuck sawmill on Friday. Analyzed the logging operations on Sr. Stambuck's hacienda and made recommendations for improved efficiency. Conducted a program on improving sawmill efficiency, mill alignment and maintenance, saw filing, and sawing techniques.

Week of October 11 - 16

To Lima, where conferred with AID officials. Travel toward Tingo Maria in College of Forest Science vehicle in company of head of forestry school and two FAO officials. Tire problems and a landslide prevented completion of trip which was to have offered opportunity for consultation on location and plans for forestry school sawmill at Tingo Maria. After return to Lima conferred with Sr. Flavio Bazan, Director of Servicio Forestal y de Caza regarding continuing sawmill improvement program in Cuzco Department and obtained plans of Servicio Forestal sawmill for review.

Week of October 18 - 23

Review plans of Servicio Forestal sawmill and conferred with Mr. George French, advisor on this project. Wrote first draft of report on activities in Peru.

October 25 - 26

Completed report and left for U.S.A. late on night of October 26.

ACTION PROGRAMS

1. One of the first actions following a preliminary trip to sawmills in the Quince Mil and Puerto Maldonado areas was the organization of a conference for lumbermen--sawmillers and dealers in the Cuzco area. This was held in Cuzco on the night of August 26, 1965, in the CRIF auditorium and it was well attended by CRIF officials as well as a sizable number of lumbermen. The program was as follows:

Introductory Remarks--Ing. Francisco Ponce de León and Sub-Gerente.

- a. Welcome, request completion of attendance form.
- b. Brief description of this program of technical assistance to sawmill and lumber-processing operators.
- c. Preparation of questions for period at end of program.
- d. Introduction of CRIF officials and guests.
- e. Introduction of David Fielding, James Evrard, Peace Corps Volunteers, and Servicio Forestal personnel.
- f. Introduction of principal speaker--K. C. Compton.

Presentation of Material by K. C. Compton.

- a. Introductory remarks.
- b. Film "Easier Methods of Logging."
- c. Major points of program.
 - (1) Separation and storage of logs.
 - (2) Sawmill setup, operation, and maintenance.
 - (3) Lumber seasoning and storage.
 - (4) Utilization of wood residues.
- d. What has been done--exploratory trip to Quince Mil and Puerto Maldonado with officials of the Servicio Forestal and Peace Corps Volunteers.
- e. Tentative program until departure date.
 - (1) Trips to Lares Valley and La Convención Valley.
 - (2) To Ccosnipata area.
 - (3) To Manu via Quince Mil.

(4) From September 16 to October 15--worked with millmen who requested assistance 1, 2, or 3 days, as necessary; training men in CRIF and Servicio Forestal to carry on the work.

f. Requests for suggestions for assistance on technical matters (individual discussions to be held at later dates with operators). AN ACTION PROGRAM--NOT A STUDY PROGRAM. Reports of technical conditions at each sawmill will be in the files of CRIF with a copy for the mill operator.

g. Make requests for assistance prior to September 16, through CRIF so that a work schedule can be prepared.

h. A general meeting of interested persons will be held if deemed justified to discuss findings and suggest further efforts.

i. Answers to written questions--officials of CRIF and K. C. Compton.

2. On September 1 and 2, a trip was made to the Hacienda Hui-Hui in Lares Valley at the request of Sres. Jesus Quintana and Miguel Carrillo to investigate and report on the potential use of the nogal (walnut) timber on the hacienda and the feasibility of a sawmill operation on the same hacienda. A report of this investigation appears in Appendix B.
3. In conjunction with a trip made to the Ccosnipata area to acquaint the sawmill operators in this area with our program and to offer our services, we studied the sawmill now being operated by the Army Engineers at their headquarters camp on the Rio Salvación. A copy of this report appears in Appendix C.
4. A study was made of the haciendas owned and operated by Sr. Alberto Ugarte and Sr. Juan Stanbuck about 15 miles from Quince Mil on the road to Cuzco. In addition to reviewing the timberlands and advising the owners on steps to develop their timber production, we held a sawmill improvement demonstration at the sawmill on Hacienda "Cadena" owned and operated by Sr. Stambuck. A report of the study of the timberland and an outline of the demonstration appear in Appendixes D and E.
5. Additional action programs included a day with Sr. Monje who operates a sawmill near Pilcopata in the Ccosnipata area. This project included reviewing his production equipment, his plans for a second sawmill, and the development of a parquet flooring operation. His present sawmill was checked for its operating characteristics.
6. In Puerto Maldonado sawmill owner, Sr. Gaston Metzger, requested assistance in determining his mill efficiency. A long session of checking mill alignment, advising on saw fitting, filing, and operation of the mill for greater efficiency followed.

7. In Cuzco long discussions were held with lumbermen and secondary wood-product processors, as well as with engineers and architects, in order to determine the factors influencing the lumber industry in the area. The results and conclusions of these discussions and conferences appear scattered throughout this report.
8. Two requests for technical assistance from owners of sawmills in La Concepción Valley and Manu were not filled because of transportation complications. It is planned, however, that both sawmill operations will be serviced during the follow-up program.

APPENDIX B: REPORT OF STUDY OF COMMERCIAL POSSIBILITIES FOR WALNUT TIMBER
(NOGAL) ON HACIENDA HUI-HUI OWNED BY MIGUEL CARRILLO

INTRODUCTION

At the request of Sr. Jesus Quintana of Cuzco, James Evrard and I traveled by DRIF vehicle in the company of Sr. Uberto Quintana and a CRIF chauffeur to the Hacienda Hui-Hui in the Lares Valley where we had been informed that there were extensive volumes of Peruvian walnut (Juglans neotropica). The purpose of our visit was to examine representative samples of the standing timber in order to evaluate the size and quality of the trees for potential lumber or veneer production. A sizable number of trees were examined along the Yanatili River and above the river in the coves formed by small streams flowing into the major river. Although this is only a sample of the walnut that is available in the area, we were informed that it was representative of the timber. However, we were told that many trees in other sections of the Lares Valley and in branches of the valley were larger than those we saw.

OBSERVATIONS

The trees which we examined were in the vicinity of Sr. Miguel Carrillo's hacienda, both on the slopes above the riverbottom and in the cove formed by a stream emptying into the river. The largest tree was 60 centimeters in diameter at 1 1/2 meters above the ground level. Of all the trees it was the only one which had potential for an export veneer log. Several other trees were of a type which could be sawn into flitches for lower grade veneer, but cost of extraction and transportation would probably be greater than return if they were to be sold for export. In addition, there were a few large trees, the trunks of which showed numerous indicators of interior defects. These trees would at best produce only lumber, probably well suited, however, for furniture parts.

There were many saplings and trees below 35 centimeters in diameter which had long, clear trunks, and these trees should not be cut immediately, because they will add greatly to their quality and volume during the next few years. Most of these trees appeared to be healthy and growing at a moderate rate under favorable soil and moisture conditions. That delaying the cutting of the better young trees will in all likelihood provide a substantial increase in income at a later date, particularly if good markets have been established in the meantime.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the walnut trees which were observed, it is doubtful that enough logs of veneer quality could be produced to fill a continuing export market. However, in the event that a decision is made to attempt to export some logs for immediate cash return, the best prices for walnut logs are paid by Italian, German, and Japanese buyers; this is true at least for logs exported from the U.S.A. Representatives of these countries are undoubtedly in Lima and could be reached through legations there.

There is at the present time little, if any, market for walnut lumber for export. A number of U.S.A. firms have attempted to import Peruvian walnut lumber but their experience with drying difficulties and color, particularly on stock cut thicker than 2 inches, has caused an unfavorable impression. If the partners are unable to find a sawmill which will buy the walnut in the form of logs for conversion to lumber, the only alternative would appear to be the establishment of their own small sawmill on the hacienda. This they plan to do when financing becomes available.

Under the harvesting and lumber manufacturing plan which has been proposed for the large area of rain forest on the hacienda, the proposed sawmill is to be set up in the highland forest area so that logs can be skidded directly to the mill tractor. Lumber is to be transported by truck to a level area at lower elevation where conditions are better for stacking and drying. If a decision is made to harvest the walnut which is marked for cutting by forestry personnel, it would be desirable to set up the mill near the hacienda so that logs need not be transported to a high elevation for sawing. When enough walnut has been sawed to provide opportunity for economic expansion the mill could be moved to the site chosen for cutting the upland forest.

Markets for walnut lumber will probably be primarily furniture and cabinet manufacturers. If examination of the Cuzco manufacturers indicates that they are unwilling to develop and promote lines of walnut products, the members of the partnership should go to Lima firms. These need not necessarily be the largest manufacturers but should be firms that have shown a willingness to design and manufacture a high-quality line of products. One source of assistance could be members of the staff of the College of Forest Science of the La Molina Agricultural University near Lima. At least a couple of these faculty members have surveyed the lumber industry in Lima, and they will provide assistance.

The members of the walnut lumber-producing firm should avoid buying machinery that is too light to operate efficiently with the size of logs which will come from the mountain rain forest. It is possible that they could obtain a heavier sawmill, used but reconditioned, from a reputable sawmill manufacturer in the United States. Quite often U.S. firms accept good used sawmills as partial payment for the highly mechanized sawmills which are much in demand at present.

Another major endeavor should be the construction of a dry kiln in which lumber cut for furniture and cabinet manufacturers could be dried to moisture contents suitable for these purposes. Although modern dry kilns can be quite expensive if brought from commercial manufacturers, it is possible that a feasible design could be drawn up for a simple kiln using wood and adobe construction. It could be heated by combustion of sawdust and slabs with air circulation accomplished either by gas-motor-driven fans or natural air currents.

APPENDIX C: REPORT OF OBSERVATIONS MADE ON THE SAWMILL OPERATED BY THE
PERUVIAN ARMY ENGINEERS IN THEIR CAMP ON THE RIO SALVACIÓN,
MADRE DE DIOS DEPARTMENT, SEPTEMBER 7, 1965

(As presented to Col. Gomez of Peruvian Army Engineers, Cuzco)

General Information

This is by far the best sawmill seen in southern Peru. It is located on a good site and set up on a concrete slab so that no difficulty should be experienced in keeping it aligned and leveled. The equipment is well-engineered and well-built, and there is sufficient power to obtain high production rates. The present production is about 1,500 board feet per 8-hour day or about one-sixth to one-tenth the designed capacity of the sawmill.

Storage space for logs is somewhat limited so that when weather conditions prevent logging, the mill will run out of logs in a few days. The small amount of lumber being produced is now used green for camp construction and furniture or it is separated by species and size and stored in a well-built shed.

The following comments and suggestions are made with the intention of contributing to greater efficiency and improved production:

1. The major deterrent to higher production is that some very large logs are being sawed. It is common knowledge in the sawmill industry that it is just as uneconomical to saw logs which are too large for the sawmill as it is to saw logs that are too small. The large logs cause delays because they require the efforts of the entire crew to move them from the yard to the log deck. It sometimes takes an hour or more to transfer them. Secondly, once they are on the carriage the first slab cut leaves several inches to a foot of wood above the saw line, and this must be chopped through. When the large logs are turned on the carriage it requires the services of the entire regular crew plus the assistance of available crew from the other units of the sawmill.

Suggestions for Improvement

- a. Leave any log that is over 38 inches in diameter in the woods or provide a means for splitting logs that exceed this diameter with chainsaws, dynamite or wedges.
- b. Provide a simple handling device for moving logs from the yard to the log deck. A heavy crane built of large timbers could be made up by the shop crew, and a manual winch would be sufficient to skid the logs into position in front of the log deck.
- c. If the services of a truck with a winch could be obtained to roll a supply of logs to the deck, a crane would not be necessary. However, the crane could be

used to turn the logs, also, by running the line through a snatch block located over the carriage and supported by a heavily braced frame. This can be easily designed by a civil or mechanical engineer.

2. Another major deterrent to greater production is the failure to utilize the full power of the diesel motor in feeding logs to the saw. The specifications for this mill state that the GM motor has a continuous rating of 159 hp. at 1,800 rpm. Apparently, there is a misunderstanding regarding the horsepower and rate of feed of the logs through the headsaw. The mill is being operated as though the horsepower is roughly one-half what it actually is, and even on softwoods feed rates seldom exceed 125 feet per minute. This is slightly more than one-half the rate of which the mill is capable. On faces which have a depth of cut of 12 inches or more, or when the wood is very hard, the feed rate must be reduced to some extent, but even under these conditions it should be faster than the present rate of feed.

Suggestions for Improvement

- a. Train the sawyer to feed at all times as fast as the saw will run without leading in or out or overloading the gullets.
 - b. Check the feed rate with stopwatch to determine if the designed rate of 230 feet per minute can be obtained. If not, the hydraulic feed mechanism should be checked.
 - c. The return rate of this carriage is very fast, and its speed should be utilized.
3. The sawyer on the whole is grinding the high-speed steel bits quite well except for the edger where the teeth were not ground square across the face, resulting in the lumber feeding in an arc through the edger. The bits are presently ground by holding them by hand against the flat face of a shop-grinding wheel. They are ground without any guide or jig, and by this method no two teeth can ever be sharpened exactly alike. It is important for the proper operation of the sawmill and for prevention of damage to the saws that saw bits be ground square across, that the original cutting angle be maintained and that they be kept as nearly the same length as possible.

Suggestions for Improvement

- a. Major Reátegui has been given the names and addresses of the manufacturers of portable electric grinders (one type is the Andrus Electric Saw Grinder, Corley Manufacturing Co., Chattanooga, Tenn.) that can be used to grind the saw teeth on the headsaw and the edger without removing

the teeth from the saws. The following are important points regarding the use of a grinder.

The grinding head turns at fairly high speed and if the stone is held against the tooth too long or with too much pressure, the heat of friction will affect the temper and damage the tooth. The stone should be pulled quickly and lightly against the face of the tooth several times to prevent overheating. There are adjusting screws on the side of the jig by which the grinder can be set for the two types of teeth in the headsaw and the edger. It will take practice and patience to learn how to adjust it properly so that the teeth are filed straight across. The adjustment for filing the face of the tooth to maintain the original cutting angle is a large eccentric cam on the side of the grinder frame. By loosening the nut holding this cam and turning the cam, after the other adjustments have been made and the grinder is clamped on the saw, the grinding stone angle can be changed to fit the face of the tooth. It may take some readjustment of the position of the grinder on the saw, but a little patience, along with trial and error, will soon set it right. Once set, the grinding procedure is rapid and the teeth are ground almost exactly alike.

- b. Until the electric grinder is obtained one of the shop mechanics should build a simple, rugged jig which can be clamped to the tool rest on the shop grinder. This jig should be adjustable so that the teeth can be clamped in it and pivoted or pressed against the grindstone's flat face at the correct angle horizontally and vertically.
- 4. According to the manual the hydraulic system operates on about 1,100 psi. Regular checks should be made to determine if this pressure is being attained, because the hydraulic lift arms and stops on the log deck appear to be very sluggish and without the power they should have. This might account, also, for the sluggish action of the carriage feed and return.

Suggestions for Improvement

- a. Institute a regular check of the hydraulic system, including reservoir level, pump drives, and pressure. The line to the pressure gauge must be closed during mill operation and opened only for checking the pressure before operation.
- b. Have a mechanic check the hydraulic cylinders to determine if they have been set for proper action. Most hydraulic cylinders have adjustments that affect the speed with which they operate, and this could be the case here.
- c. Straighten the lift arms on the log deck.

5. There are insufficient hand tools to perform the necessary manual labor around the mill. There was only one cant hook, and the handle on that was broken so that its efficiency was only about half what it could have been. At least one axe being used for chopping slabs and boards from the logs had a loose head--a very dangerous condition for the user and anyone nearby.

Suggestions for Improvement

- a. Acquire at least three large peavies and two cant hooks of a smaller size for turning logs on the carriage. Make a regular inspection of handles in peavies, cant hooks and axes and replace them if they are cracked or broken.
6. Chainsaws are a very valuable tool around a sawmill for trimming or splitting logs, and performing some of the work now done with axes. At present no chainsaw is available to the sawmill crew.

Suggestions for Improvement

- a. Select a chainsaw with the highest available horsepower and longest cutting bar for assignment to the sawmill crew. Select one or two men to train in the use, maintenance, and sharpening of the saw.
- b. Use the chainsaw to rip any log over 38 inches in diameter into halves or quarters.
- c. In the event the headsaw does not completely sever a slab or board, the chainsaw can be used to rip the slab or board from the log.
7. In general the mill is kept clean but there are a couple of suggestions that might prevent an accident. Safety is an important factor in the operation of any sawmill.

Suggestions for Improvement

- a. Keep the offbearing end of the mill, where the slabs are removed, clear of heavy slabs and chips from chopping. The footing is very insecure and someone could be hurt by stepping on a slab or chip while handling lumber.
- b. Issue instructions that when the sawmill is running no one is to walk around the headsaw on the carriage track side under any conditions. A slip would mean amputation or a dead soldier.

APPENDIX D: AN APPRAISAL OF TIMBER STANDS AND SAWMILL OPERATION ON THE
HACIENDA OF SR. ALBERTO UGARTE AND SR. JUAN STAMBUCK NEAR
QUINCE MIL, CUZCO DEPARTMENT

During the week of October 4-8 reconnaissance was made of the timber on two haciendas on the road about 15 miles toward Cuzco from Quince Mil. At one time these haciendas were primarily producers of sugarcane, and the flat areas along the river and on each side of the road were cleared for this purpose. The land rises steeply from these flats in typical mountain selva, and on these steep slopes there is a thick stand of timber composed of many species. At present three lumbering operations are being conducted, each of which is producing some logs for the sawmill at Hacienda "Cadena" operated by Sr. Stambuck. Each area has a frame for pit sawing lumber, and this method of producing lumber is draining potential logs from the sawmill. Inasmuch as the sawmill is having difficulty getting enough logs to fill its needs it would be advantageous to discontinue pit sawing, except to halve or quarter logs which cannot be handled by the logging equipment, or which are too large for the sawmill.

A small crawler tractor is available, but it is too light and under-powered to perform the necessary skidding operations. As a result, logs are being rolled out by hand and moved on skid poles laid on the ground. This limits the size of logs which can be moved. It is recommended that the owners invest in a chainsaw and train a couple of operators. This would eliminate a chronic labor shortage and permit both slabbing and splitting logs in the woods. Also, it is recommended that the owners investigate the acquisition of a crawler tractor in the 65 hp. class with blade and winch. A simple cable skidding system (gravity with descent control) should be devised for bringing logs from the very steep slopes to the lower levels. Some form of increased log production must be achieved, inasmuch as the operators plan to step up their lumber production at the sawmill.

The sawmill is well constructed on concrete foundations with wood frame members to resist shock and vibration. The mill is floored with poured concrete, has a good roof, and is quite spacious. Arrangements for handling lumber are very poor, however, and a great deal of modification needs to be done to improve production. The carriage trackway and the husk frame need to be raised about 30 inches, so that lumber will come to the headsaw off-bearer at about waist height. Lumber rolls should be installed, and an edger purchased and set in the lumber flow line. The present rip table is inadequate for edging lumber, but the present trim saw is satisfactory. The latter should be turned to permit lumber to come to it in a straight line from the lumber rolls and edger.

This mill has a good power unit, but the owner should check with the manufacturer's representative in Lima to learn if the motor is developing the maximum horsepower of which it is capable for sawmill duty. Transmission of power from the motor to the saw mandrel is definitely inadequate. A 5-inch belt is too small for 85 hp. and a 58-inch saw. The belt should be at least 8 inches wide.

The major deterrent to successful mill operation is the headsaw itself. It is quite old, and is very loose in the center. The saw teeth holders are

worn out, and the saw has a crack running from the mandrel hole in a radial direction. Emergency repairs have been made by riveting a plate on each side of the center, but this saw should be replaced as soon as possible in order to cut lumber better and faster. One problem with maintaining saws in Peru is that saw teeth and holders are very expensive and apparently some sizes are not stocked inside the country. This makes replacement very time-consuming and expensive.

The owners and operators of this mill and the timberlands have an excellent potential, even though their timberlands may not have as high a proportion of the high-value trees as some areas. Equipment is very well maintained, with the exception of the saw mentioned above. The operators appear to have good business judgment as well as respect for machinery.

APPENDIX E: A SAMPLE DEMONSTRATION OF SAWMILL IMPROVEMENT PROGRAM

Place: Stambuck's hacienda: "Cadena"

Date and time: Friday, October 8, 1965, 10:00 a.m.

Participants to be invited: Stambuck, Zlater, Kalinowski, Pilares, Ortaru, Barten

PROGRAM

Lectures and Demonstrations

A. Woods operations.

1. Lumber begins in the woods.
 - a. Selection of trees to cut--species, size, quality.
 - b. Bucking logs to obtain best grade and to meet the market requirements.
 - c. Log making for better handling and transportation trim allowance.
2. Restriction on log making.
 - a. Cut only those logs that manufacturing equipment will handle. Restrict diameter of logs to not more than 4 inches over opening of carriage, unless have means to split the logs.

B. Mill alignment and maintenance.

1. Checking mill alignment.
 - a. Plumb, level, and square.
 - b. Lead.
2. Mechanical condition.
 - a. Foundations, carriage and husk frames.
 - b. Saw collars.
 - c. Condition of saw--lumps or twists.
 - d. Mandrel and bearings.
 - e. Guides.
 - f. Head blocks, and position with respect to guides.

- g. Setworks--pinions, ratchets, pawls.
 - h. Knees--freedom from play and wear, angle to base.
3. Checking the saw.
- a. Tooth filing and fitting.
 - b. Holders--condition.
 - c. Proper tooth angles, swaging.
 - d. Inserting new teeth and holders.
4. Mill location.
- a. Topography to move materials by gravity.
 - b. Area for storage and seasoning.
 - c. Disposal of waste.
5. Sawing demonstrations.
- a. Normal logs.
 - b. Large logs.

APPENDIX F: DESCRIPTION OF SAWMILL INFORMATION SERVICE

Date: October 15, 1965

Prepared by: Peace Corps Volunteers James Evrard and David H. Fielding

A. Primary description.

1. Organization and responsibility.

- a. Initially, the Sawmill Information Service will provide technical bulletins to be sent approximately every 2 to 3 weeks to all persons involved in sawmills in the Departments of Cuzco and Madre de Dios. Each edition of this bulletin will discuss one major topic dealing with the maintenance and operation of sawmills or with any other topic relevant to the forest industry in Peru. The staff of SIS will consist of essentially five people, other than temporary contributors. These will be the director or editor of the publication, an English-to-Spanish translator, and three technical advisors: James Evrard, David Fielding, and Peter Moller. All of the latter are Peace Corps Volunteers with experience in the lumber industry.

2. Purpose.

- a. The primary purpose of the SIS would be to provide technical aid to the lumber industry in the Departments of Cuzco and Madre de Dios, where at present no technical aid is available. This aid would be in the form of the previously mentioned publication and the assistance of the technical advisors who would visit any individual requesting on-the-spot advice. The SIS would be a direct follow-up to the work done by Mr. Kenneth Compton during his 2-1/2-month stay in Cuzco as a sawmill specialist under USAID contract with the Corporación de Reconstrucción y Fomento del Cuzco.
- b. The secondary purpose of the SIS will be to increase production and quality, including a general standardization of the lumber products. This would have the effect of increasing the market demand, and insuring the dependability of the product.
- c. The third basic purpose, which will be a combination and result of the first two, would be that of facilitating the formation of a lumberman's association and the establishment of standards throughout the industry. Until the industry is standardized and the customer can depend upon the quality of the product, no major advancement can be realized; the SIS hopes to solve this problem.

3. Budget--for the capacity of this service and the opportunities which it would present to the lumber industry in this region, the budget would be virtually insignificant. It should consist basically of the following.

- a. Office supplies--paper, ink, pens, typewriter, etc.
- b. Publication expenses--paper, reproduction, mailing, and file costs.
- c. Translation costs.
- d. Traveling expenses of advisors when requested for specific technical aid.
- e. Employment of editor or person responsible for the program.

4. Format of publication.

- a. Each edition will discuss one major topic.
- b. The publication will contain a question and answer column.
- c. When possible, a list of new and available equipment will be presented with the address of the supplier and price estimates.
- d. The publication will have a name other than Sawmill Information Service.
- e. Each edition will have a heading, a list of the staff, and the address to which people may write requesting technical visits.
- f. When possible, Spanish copies of technical books will be distributed with the SIS publication.

5. Origin of materials.

- a. U.S. Forest Service.
- b. Servicio de Forestal y Caza de Lima and Cuzco.
- c. La Molina Agricultural University.
- d. Peruvian Forest Journal.
- e. Forest magazines.

(1) Forest Industries

(2) World of Wood.

(3) Journal of Forestry.

(4) Any other available and relevant publications.

f. Sawmill owners themselves.

g. USAID and Peace Corps sources.

B. Suggested topics.

1. Lumber drying.
2. Logging methods.
3. Chainsaw application.
4. World lumber industry.
5. Sawmill maintenance (over two or three issues).
6. Efficient use of horsepower.
7. Sawmill and lumberyard bookkeeping.
8. Handling large logs at sawmill.
9. Lumber standards and grading.
10. Export market.
11. Market improvements and advertisement.
12. New products.

C. Parties scheduled to receive the publication (preliminary).

1. Quince Mil

- a. Juan Stambuck--Hacienda Cadena
- b. Juan Zlater
- c. Leon Kalinowski--La Punta
- d. Hector Pilares--Santa Marta
- e. Julio Ortaru
- f. Alberto Ugarte--Casilla 127, Cuzco

2. Puerto Maldonado

- a. Momba, S. A. (Plywood plant)
- b. Aserradero Modesa (Metzger)
- c. Rob, S. A.

3. Manu

- a. Carlos Lomalini and partner, Barten
- b. Benedicto Kalinowski

3. Ccosnipata

- a. José Szkuta--Chuntachaca
- b. Guillermo Rojas--Chuntachaca
- c. Partners Monje and Rodriguez--Pilcopata
- d. Iwaki--Patria
- e. Suero--Patria
- f. Julio Ricardo Perez--Carbon
- g. Peruvian Army Camp--Salvación

4. Lares and Quillabamba

- a. Jesus Quintana and Miguel Carrillo--Hacienda Hui-Hui in
Lares Hacienda de Té Marin in Quillabamba

This makes a total of 20 copies. Allowing for filing and extra copies, approximately 30 copies will be made of each edition.

APPENDIX G: SAWMILL CHECKLIST

Name and location of mill _____
Name of owner _____
Address of owner _____
Name of person providing information _____
Age of mill _____ (if unknown give general estimate),
and make _____
Condition of the equipment: good _____ poor _____
Mill clean and orderly _____ or dirty and cluttered _____
Source of power: gasoline _____ diesel _____ steam _____
water _____ Approximate horsepower _____
Auxiliary equipment present: edger _____ trimmer _____ planer _____
sawdust chain _____ log turner _____ lumber rolls _____
other _____
Mill running _____ What are operating months _____
Production/day _____ bd. ft. Hours worked/day _____
Production/hour _____ Number men in manufacturing _____
Production/man hours _____
Air seasoning practices and kiln drying _____

How well is mill set up (on concrete or wood, ground level or above, etc.)

Markets for lumber _____

What are major problems (your estimate and the owner's) _____

What is potential of this mill _____

Use back of sheet for sketches, mill layout or additional data.

APPENDIX H: SAWMILL IMPROVEMENT PROGRAM FOR SOUTHERN PERU

AGENCIES AND PERSONS CONTRIBUTING TO THE MISSION

U.S. State Department

Washington, D.C.--Dr. Eileff Miller, LA/ID

Lima, Peru--Robert M. McConnell

Agency for International Development

Washington D.C.--William R. Dalton, Virgil C. Peterson, Stephen Bergen

Lima, Peru--George J. Greco, George R. Lindahl, Jr., Torkle Holsoe

Cuzco, Peru--Earl E. Smith

International Agricultural Development Service

Washington, D.C.--Matthew Drosdoff, A. J. Nichols, Ralph U. Battles,
Marshall Fox, Fred Thompson

U.S. Forest Service

Washington, D.C.--H. O. Fleischer, John T. Drow, Robert K. Winters,
Carl E. Ostrom

Peace Corps Volunteers

Cuzco, Peru--Lawrence Cornish, David Fielding, James Evrard, Peter
Moller

FAO-UNSF

Lima, Peru--La Molina Agricultural University, School of Forest Science--
Dr. John Yavorsky, Dean Adolfo Salazar, Dr. Seymour Somberg, Prof.
Leevi Lakio

FAO/Rome--Dr. Nils Osara (visiting FAO/Lima)

Centro Nacional de Productividad (CENIP)

Lima, Peru--Sr. Jorge Succar, General Director

Cuzco Reconstruction and Development Corp. (CRIF)

Cuzco, Peru--Ing. Armando Gallego, Ing. Louis Yopez, Ing. Roberto
Tomayo, Ing. Francisco Ponce de León, Ing. Oscar Aguirre, Ing.
Carmen Venero

Stanford Research Institute--Charles A. Jackson, Resident Advisor to
Industrial Development Division of CRIF

Peruvian Forest Service

Lima--Director Flavio Bazan, Ing. Izquierdo

Cuzco--Ing. Manuel Iparraguirre, Ing. Uriel Yavor

Puerto Maldonado--Ing. Wilson Vela

Sawmill Owners Conferred With

Quince Mil Area

Kalinowski--La Punta on Inambari River

Ortaru--Quince Mil

Pilares--Quince Mil

Stambuck and Ugarte--Quince Mil

Zlater--Quince Mil

Manu

Barten and Lomalini (did not visit mill because of transportation problems)

Lares Valley

Quintanu--Carrillo (mill not installed at time of visit)

Ccosnipata Area

Army Engineers--camp at Rio Salvación under command of Lt. Col. Salinas

Iwaki--Patria

Monje and Rodriguez--Pilcopata

Perez--Carbon

Rojas--Chontachaca

Suero--Patria

Szkuta--Chontachaca

Puerto Maldonado

Metzger

Roberts

Yurimaguas

Hacienda San Ramon--reviewed plans for new mill installation
with Domingo Loero, Jr., Domingo Loero, Sr., and William Collins

Iparia

Peruvian Forest Service--reviewed plans for new mill installation
with Sr. Flavio Bazan, Mr. George French

Tingo Mario

School of Forest Science, La Molina Agricultural University--
reviewed plans for mill installation with Dr. John
Yavorsky and Prof. Leevi Lakio



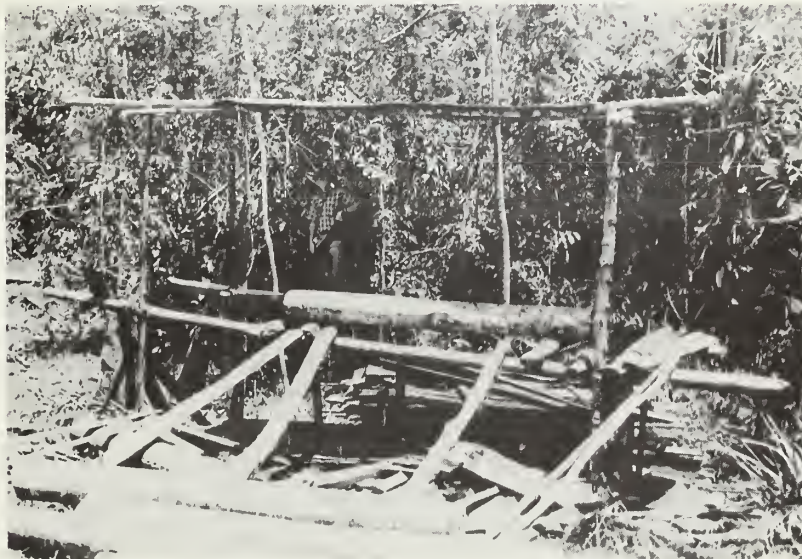
1. Forest conditions in foothill forest near Quince Mil.



2. After logging. Note skid poles on ground used for rolling logs (same general area as photo No. 1).



3. Deck of logs in foothill forest. Logs will be rolled down steep slope at far end of deck.



4. Frame for pit sawing logs into lumber.



5. Lumber produced by pit sawing was surprisingly well manufactured.



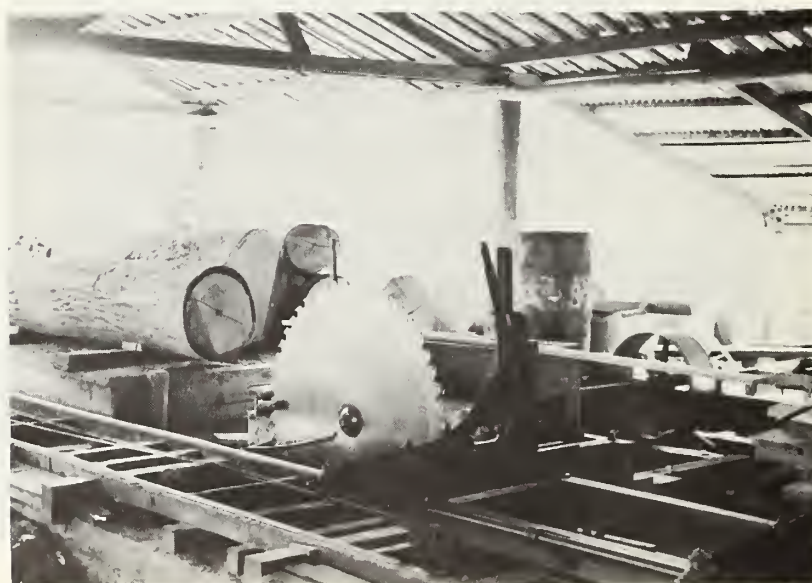
6. Unloading "corriente" logs at mill near Quince Mil.



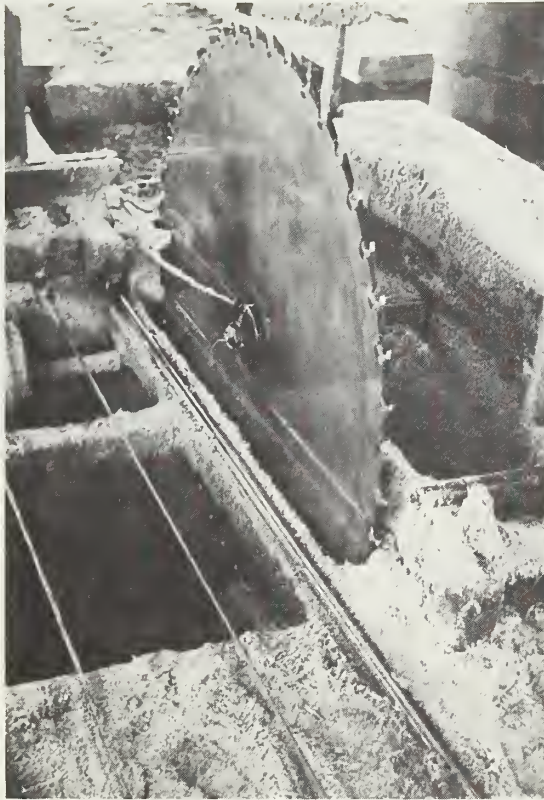
7. Cedro logs at mill in Puerto Maldonado.



8. Four-foot rule on end of logs at mill in Puerto Maldonado.



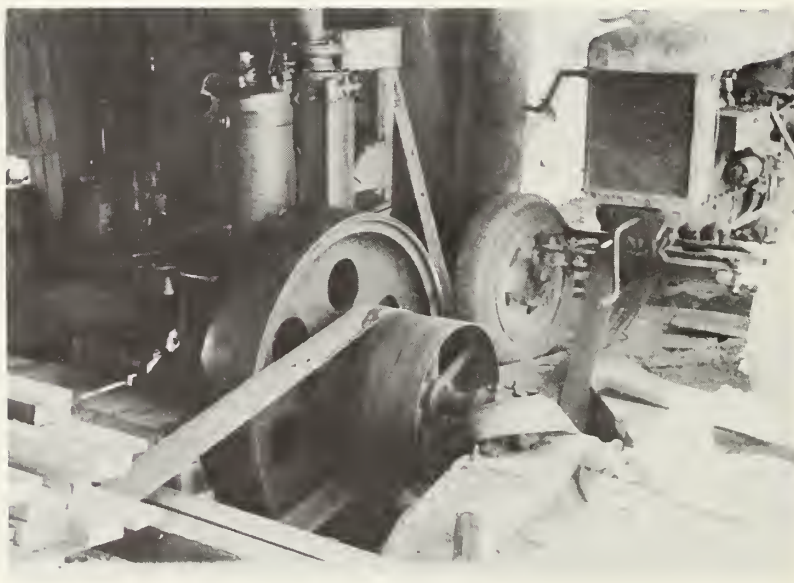
9. Well-maintained mill in Puerto Maldonado.



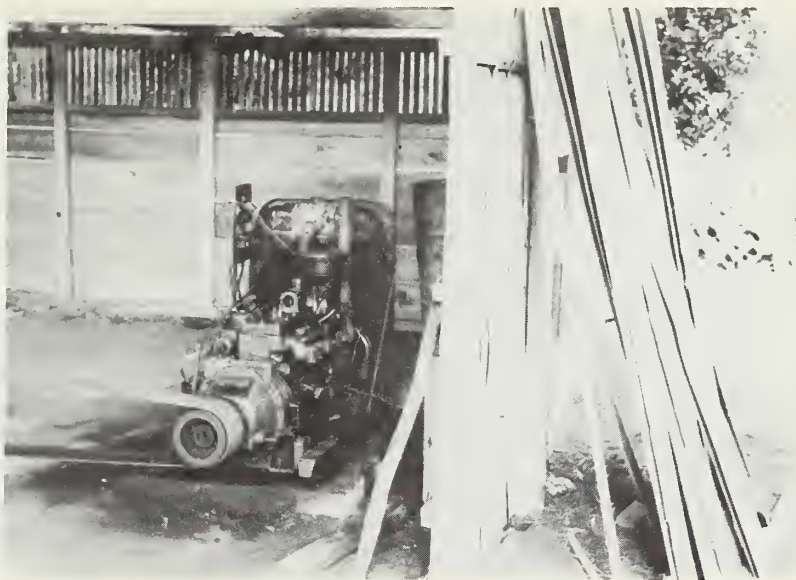
10. Six-gauge saw with chrome impregnated saw bits of $21/64$ -inch Kerf.



11. Mill in process of changing from 30 hp. gasoline-powered tractor to 20-foot-diameter waterwheel.



12. One-cylinder diesel engine--about 60 hp. Note heavy fly-wheel.



13. A gasoline industrial motor--about 85 hp.



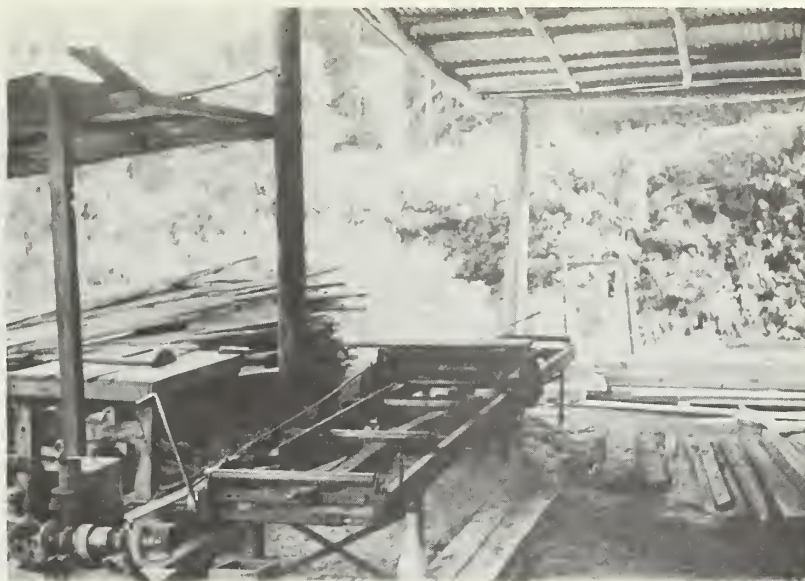
14. Diesel engine of about 85 hp.



15. Peruvian Army Engineers' mobile mill. Very large log sizes slowed production in this mill.



16. Peruvian Army Engineers' three-saw edger and power unit.



17. Edger set at right angles to rest of mill. This is one of the few edgers found in the mills of southern Peru.



18. Heavy timbers at left for shipment to Cuzco where they will be resawed.



19. Good sorting of lumber before shipment to Cuzco, but no seasoning.



20. Cedro lumber X-racked for seasoning before shipping by air. Warping is a problem.



21. A planer increases this operator's market potential.



22. Sawmill demonstration--checking lead.



23. Sawmill demonstration--a level on the headblock base checks the track condition as the carriage moves.



24. Sawmill demonstration--fitting new teeth in saw.



25. Sawmill demonstration--checking saw filing.



26. Sawmill demonstration--a saw filing lesson.



